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STABILITY OF MORPHOLOGICAL TRAITS OF MAIZE SEED UNDER DIFFERENT PRODUCTION CONDITIONS

STABILNOST MORFOLOŠKIH OSOBINA SEMENA KUKURUZA U RAZLIČITIM PROIZVODNIM USLOVIMA

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ABSTRACT

The analyses were performed with the hybrid seeds of four hybrid combinations derived at the Maize Research Institute, Zemun Polje and produced in three locations. Under laboratory conditions, the following seed traits were analysed in the working sample of 10x100 seeds: seed test weight and shelling percentage, which was determined as the seed weight to ear weight ratio. In the three-year study, the greatest (352.71 g), i.e. smallest (280.09 g) test weight was recorded in the hybrids ZP 434 and ZP 704, respectively. The highest shelling percentage of 60.53 % was determined in the hybrid ZP 704, while the lowest one (48.20 %) was recorded the hybrid ZP 434.

Obtained results point out that both traits in all four hybrids are highly expressed under all observed agro-ecological conditions and that effects of factors on the seed weight and the shelling percentage are great.

***Key words**: maize, hybrid, weight, shelling percentage.*

REZIME

U ovim istraživanja posmatrane su masa 1000 semena i randman semena, u odnosu na genotipsku kombinaciju i agroekološke uslove prozvodnje semena.

Analize su rađene na hibridnom semenu četiri komercijalne hibridne kombinacije Instituta za kukuruz „Zemun Polje“, proizvedene na tri lokaliteta. U laboratorijskim uslovima, na radnom uzorku od 10x100 semena, izvršena su ispitivanja apsolutne mase semena, randman semena utvrđen je kao procentualni odnos mase semena i klipa. U trogodišnjem istraživanju najveća izmerena masa 1000 semena je kod hibrida ZP 434 (352,71 g) dok je ZP 704 hibrid sa najmanjom postignutom masom(280,09 g). Randman semena najveći je kod ZP 704 (60,53%), najmanji 48,20% kod ZP 434. Lokalitet sa najvećim variranjem mase bio je Turija (41,58%), a druga osobina najviše varijabilnosti u toku istraživanja bila je na lokalitetu Vrbas (28,13%).

Eksperimentalni podaci obrađeni su na srednju vrednost i ukupnu varijabilnost (x i C.V.) za obe osobine semena i svaku varijantu istraživanja. Dvofaktorijalnom analizom varijanse utvrđen je uticaj faktora (hibrid i lokacija), kao i njihova interakcija na ispitivane osobine semena.

Dobijeni rezultati pokazali su da sva četiri hibrida imaju visok nivo ispoljavanja obe osobine u svim posmatranim agroekološkim uslovima, kao i visok uticaj faktora (hibrid i lokacija) na masu semena i randman semena.

***Ključne reči**: kukuruz, hibrid, masa, randman, varijabilnost.*

INTRODUCTION

The necessary and adequate number and distribution of plants in the commercial crop of hybrid maize may be provided primarily by sowing seeds of good physiological, physical, and mechanical traits.

Physical and mechanical, as well as physiological, traits of hybrid maize seed depend on agro-ecological conditions during seed development and maturation. *Shien and Mc Donald (1982)* studied the influence of seed size and shape of two maize inbred lines and established that the seed quality did not depend on its size. There are numerous manuscripts published in our country devoted to the significance of the seed shape and size and their effects on germination (*Đukanović et al., 2003; Pajić et al., 1997)*. According to results stated by *Chassot (2000)* air and soil temperatures within the no-tillage system are probably the main physiological stress factor during the early development of the maize plant. *Stone et al. (1999)* have determined that the soil temperature directly affected meristematic tissues of radicles and shoots.

Furthermore, all traits of hybrid maize seed depend on the genotypic combination and interactions of this combination with agro-ecological conditions during the growing season of the seed crop. *Lee et al. (2002)* indicated that significant differences in tolerance to low temperatures were related to a genotype. These differences were manifested in different development rates of both the root and the above-ground shoot.

The research programme encompassed experimental studies of traits of F1 hybrid seed, mathematical and statistical processing, the evaluation and analysis of obtained experimental data.

MATERIAL AND METHOD

Seeds of hybrid combinations ZP 341, ZP 434, ZP 684 and ZP 704, produced in three locations in Bačka (Vrbas, Orahovo, Turija) were used as a material in this study.

The material was produced with the application of similar cropping practices. Production trials for each hybrid combination were set up according to standards prescribed by the *Regulation on control of the seed production of the agricultural crops (Official Gazette of the Republic of Serbia, issue 60/2006).*

In the process of seed production, agro-ecological conditions were monitored, while the data were obtained from the closest meteorological stations.

Working samples of 1000 g were drawn from the 20-35 kg processed seed material (size seed fraction 6.5-11.0 mm) and were used in the analysis of morphological traits. Under laboratory conditions, the test weight was determined on the sample of 10x100 seeds. The shelling percentage was determined from the ratio of ear weight to seed weight obtained after processing. 10x10 ears were working samples for shelling percentage determination.

Gained experimental data were processed by the appropriate mathematical and statistical methods using the software package IBM SPSS Version 19. Each of obtained parameters was processed by the statistical analysis using descriptive statistics for parameters at the annual level (form the first to the third year of investigation). The differences among analysed hybrids (four) in three locations in Bačka were established by the analysis of variance for the factorial trial set up according to the randomised complete-block design, as well as by the LSD test for the probability levels of 5 % and 1 % *(Šošić, 2006)*. Homogeneity of variances was assessed by the Levene's test in order to draw more objective conclusions on effects of observed factors on studied traits of maize seed as well as the possibility to apply parametric tests (ANOVA and LSD-test).

RESULTS AND DISCUSSION

The seed size is under genetic control, but also under control of environmental factors. In dependence on genetic factors, biochemical and physiological plant ability, as well as on temperature, moisture and the presence of accessible nitrogen in the soil, the duration and the rate of seed filling are different which result in a different seed size (*Sadras and Egli, 2008*). *Obhaimbo and Compton (1987)* have determined that small seeds affected the increase in the number of seeds per area (m^2), but also resulted in the yield reduction. On the other hand, large seeds have significantly affected the maize yield increase.

In the first year of investigation, the changes in the 1000-kernel weight were affected by the location (Table 1). Hence, the greatest (339.27 g), i.e. smallest (306.08 g) 1000-kernel weight was recorded in the locations of Turija and Vrbas, respectively.

Variability of samples drawn in the second year was not expressed among hybrids nor among locations (Cv<8 %).

The changes of the 1000-kernel weight were also affected by the location. The greatest, i.e. smallest 1000-kernel weight was recorded in the locations of Orahovo (338.94 g), i.e. Turija (265.21 g), respectively. A significant difference in the 1000-kernel weight between these two locations is observed (Table 1). The greatest three-year variation was recorded in the hybrid ZP 704 (10.31 %).

Table 1. Means and variability for the 1000-kernel weight

Year	Hybrids	LOCATIONS			$\bar{x} \pm S_{\bar{x}}$	Cv (%)
		Vrbas	Orahovo	Turija		
1	ZP 341	281.92	320.46	340.24	314.20c ±4.68	7.36
	ZP 434	332.56	354.56	347.94	345.02b ±2.52	3.72
	ZP 684	346.70	335.32	375.26	352.42a ±5.25	7.68
	ZP 704	263.54	285.52	293.64	280.09d ±2.60	4.63
	$\bar{x} \pm S\bar{x}$	306.08c ±8.48	323.96b ±6.28	339.27a ±6.88		
	Cv (%)	12.40	8.67	9.07		
2	ZP 341	320.12	294.36	334.84	316.44b ±4.09	6.39
	ZP 434	299.61	298.39	310.66	302.88c ±1.90	3.10
	ZP 684	343.41	328.22	336.06	334.03a ±1.64	2.43
	ZP 704	293.82	305.94	306.22	301.99d ±2.54	4.34
	$\bar{x} \pm S\bar{x}$	314.24b ±4.60	306.73c ±3.31	321.94a ±3.78		
	Cv (%)	6.56	4.84	5.25		
3	ZP 341	314.90	340.38	387.60	347.62b ±18.57	5.30
	ZP 434	352.14	357.04	348.95	352.71a ±3.08	4.51
	ZP 684	352.10	344.24	305.76	334.03c ±4.11	6.24
	ZP 704	307.24	314.10	335.27	318.87d ±6.13	10.34
	$\bar{x} \pm S\bar{x}$	331.60b ±5.27	338.94a ±4.10	265.21e ±25.30		
	Cv (%)	7.12	5.41	41.58		

$\bar{x} \pm S\bar{x}$ *mean and standard deviation; Cv – coefficient of variance; a,b,c,d,-Different letters in a row denote significant difference at p<0.05 (Tukey HSD).*

The shelling percentage is largely determined by the observed factors (hybrid and location). The effects of observed factors on the shelling percentage were statistically very significant.

The shelling percentage was the highest in the hybrid ZP 704 (60.53 %), than in hybrids ZP 684 (59.03 %) and ZP 341 (58.16 %), while the lowest shelling percentage was determined in the hybrid ZP 434 (52.53 %). Furthermore, the highest shelling percentage was detected in seeds obtained in the location of Orahovo (59.65 %). A ssignificantly lower shelling percentage was determined in the location of Vrbas (37.52 %). (Table 2).

Variability among both, hybrids and locations, was below 30 %, which points out to homogeneity of samples.

Based on the results of statistical significance of effects of observed factors (Table 3) it is obvious that both factors (hybrid and location) as well as their interaction statistically very significantly affected changes in the 1000-kernel weight (p<0.01).

Table 2. Means and variability for the shelling percentage

Year	Hybrids	LOCATIONS			$\bar{x} \pm S_{\bar{x}}$	Cv (%)
		Vrbas	Orahovo	Turija		
1	ZP 341	40.80	43.40	48.00	58.16c ±2.26	20.42
	ZP 434	42.00	41.50	50.20	48.20d ±1.20	12.98
	ZP 684	61.20	61.10	61.80	59.03b ±0.92	8.14
	ZP 704	47.60	51.20	48.60	60.53a ±0.68	5.88
	$\bar{x} \pm S\bar{x}$	47.9d± 1.85	49.3c± 1.77	52.15a ±1.29		
	Cv (%)	17.34	16.07	11.08		
2	ZP 341	20.42	61.71	56.32	46.13c ±3.19	28.53
	ZP 434	43.74	57.45	55.13	52.06.a ±1.34	12.18
	ZP 684	39.05	56.80	56.82	50.93b ±1.39	13.45
	ZP 704	47.03	60.04	50.77	52.56a ±0.90	8.77
	$\bar{x} \pm S\bar{x}$	37.52d± 2.36	58.98a± 0.45	54.72c ±0.55		
	Cv (%)	28.13	3.44	4.51		
3	ZP 341	47.42	56.51	46.44	50.10d ±1.29	13.92
	ZP 434	56.45	61.32	39.97	52.53c ±1.58	15.88
	ZP 684	58.39	60.66	53.93	57.60b ±3.32	28.96
	ZP 704	53.54	60.20	62.15	58.60a ±0.86	7.61
	$\bar{x} \pm S\bar{x}$	53.9b± 0.94	59.65a± 0.42	51.14c ±1.91		
	Cv (%)	7.85	3.20	16.34		

$\bar{x} \pm S\bar{x}$ *mean and standard deviation; Cv – coefficient of variance*; *a,b,c,d,-Different letters in a row denote significant difference at p<0.05 (Tukey HSD)*

Hence, the values of this trait were the highest in hybrids ZP 684 and ZP 434, but their differences were not significant. At the same time, their weight was statistically significantly higher than the weight of hybrids ZP 341 and ZP 704. Furthermore, the 1000-kernel weight recorded in the hybrid 704 was statistically lower than the corresponding values in remaining hybrids (p<0.01).

Applied the statistical method of the two-factorial analysis of variance and confirmed the effect of the hybrid combination and the location on physiological and morphological traits that were the objective of the present study (*Tabaković et al., 2015; Pavlov et al., 2015)*.

The difference in the shelling percentage among observed hybrids was statistically very significant (Fuz=169**). The shelling percentage statistically very significantly differs in all hybrids (p<0.01). Moreover, effects of the location as the second factor are statistically very significant (Fuz=100**). The value of this parameter was statistically significantly higher in the location of Turija than the values obtained in remaining locations. The interaction of observed factors was also statistically significant (Table 3, first year).

In the second year of investigation, observed factors did not have only statistically very significant effect on the shelling percentage, but also had a very significant effect of activity, as indicated by the partial eta-squared (η^2=0.7661 and η^2=0.7984). Hence, both factors as well as their interaction had almost identical effect on the changes in the shelling percentage of maize.

In addition, a statistically very significant difference in the shelling percentage among observed hybrids was determined in the third year of investigation (Fuz=913**). The shelling percentage statistically very significantly differed among all hybrids (p<0.01). Furthermore, the effect of the location, as a second factor, was also statistically very significant (Fuz=261**).

Table 3. Statistical significance of differences in the 1000-kernel weight and the shelling percentage (F and LSD test)

Year	Parameters	1000-kernel weight			Shelling percentage		
		Hybr.	Locati.	Interac.	Hybr.	Locati.	Interac.
1	F-test	186.32**	30.59**	12.77**	169**	100**	143**
	LSD 0,05	5.708	6.381	12.763	0.055	0.062	0.124
	LSD 0,01	7.513	8.400	16.780	0.073	0.082	0.163
	Partial Eta Squared of value	0.874	0.604	0.657	0.886	0.867	0.868
	Levene′s test F	3.160			0.055		
	p-level	0.000			0.956		
2	F-test	212.57**	17.16**	22.91**	760**	12474**	2263**
	LSD 0,05	3.593	4.017	8.034	0.175	0.196	0.392
	LSD 0,01	4.729	5.287	15.098	0.231	0.258	0.516
	Partial Eta Squared of value	0.888	0.462	0.774	0.766	0.798	0.797
	Levene′s test F	4.3685			6.5278		
	p-level	0.0000			0.0000		
3	F-test	325.54**	170.36**	148.97**	913*	261**	794**
	LSD 0,05	5.432	6.073	12.146	0.055	0.062	0.124
	LSD 0,01	7.150	7.994	15.988	0.073	0.082	0.163
	Partial Eta Squared of value	0.924	0.894	0.957	0.777	0.765	0.774
	Levene′s test F	6.881			0.011		
	p-level	0.000			0.999		

**Significant at p<0.05 level; **Significant at p<0.01 level*

CONCLUSION

The studies of seed morphological traits of four hybrid combinations in three locations point out to:

All stated factors affect traits of hybrid maize seeds differently: indirectly and directly, via weaker or stronger interactions and in different ways;

Means and variability of traits of hybrid maize seeds point out to significance of agro-ecological effects but within limits determined by the genetic combination. The highest variability in the 1000-kernel weight was established in the hybrid ZP 704 (Cv 10.34 %). The greatest differences in values of this parameter among observed hybrids was determined in the location of Vrbas (Cv 17.34 %).

Results of the analysis of variance, i.e. values of F-test and probability of these values indicate that the effect of certain factors is not the same for the expression of each seed trait and for each hybrid combination as indicated by the values of the

partial eta-squared. The effect of the hybrid combination expressed by the partial eta-squared ranged from η^2=0.8748 to η^2=0.9243, while the effect of the location varied from η^2=0.4625 to η^2=0.8949.

Results obtained in the analysis of effects of factors on the expression of traits of hybrid maize seeds point at a primary importance of a genotypic or a hybrid combination of a given seed, that is of plant traits and synchronicity of flowering of parental lines in the seed crop.

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